I. THE SUN'S MOTION IN SPACE.

BY W. H. S. MONCK, DUBLIN.

While there is considerable amount of agreement between the various determinations of the sun's motions in space, there is also an amount of discordance which cannot be regarded as satisfactory. It may therefore be desirable to inquire whether this discordance does not arise from the employment of objectionable methods rather than from any errors in the corresponding computations. All the methods which I am aware of start with a classification of the stars whose proper motions are to be considered. Two principles of classification have been adopted by different computers—one depending on the magnitudes of the stars and the other on the amount of their apparent proper motions.

The first method commences by classing together stars of nearly the same magnitude and assuming that the stars comprised in each class are at nearly the same distance from us, while the relative distances of the different classes are computed from the average intensity of the light in accordance with the law of inverse square. To this process there are many objections. First there is strong reason to believe that stars of the same magnitude are situated at widely different distances from us. Indeed if it be true that a Sirian star is on the average nearly two magnitudes brighter than a solar star of the same mass placed at the same distance, these two kinds of stars ought not to be classed together in any inquiry in which their distances are involved. In the next place in order to construct any class numerous enough to be used in our computations we must in our earlier classes include stars which differ very considerably in magnitude. Thus in Mr. DUNKIN'S computation (*Memoirs of The Royal Astronomical Society*, vol. xxxii) there are only nine stars comprised in his first class and to obtain these he includes *Sirius* and *Spica*, whose difference in magnitude amounts to 2.66 according to the *Harvard Photometry*. The fifty-five stars in his second class include *Antares* 1.06 and δ *Leonis* 2.75; while it is pretty evident that his first class averages more than one magnitude above his second class, thus rendering the assumed multiplier inapplicable. In computing these multipliers according to the law of inverse square, moveover, it is assumed that there is no loss of light in transmission, which is also

open to considerable doubt. It is not surprising that a method which is liable to such grave objections should have yielded unsatisfactory results.

In the second method the stars are classified in accordance with their apparent proper motions, similar assumptions being made as to the distances of the respective classes as in the former instance. But in the first place there seems good reason to believe that different stars are moving through space with very different velocities, while the apparent proper motion depends not only on the distance of the star and its velocity, but also on the degree in which its apparent path is foreshortened owing to the position of the observer. But if the apparent proper motion of the stars is largely influenced by the sun's motion in space a further objection arises. Suppose, for instance, that we are considering the class of stars whose apparent proper motion ranges from $0''.08$ to $0''.12$ annually and that on the average one-half of this apparent motion is caused by the motion of the sun. The true proper motion of the class will then range from $0''.04$ to $0''.24$, and some of the stars in the class will be six times as remote (on the average) as others. An inspection of the catalogue of 1167 stars used by Mr. DUNKIN seems to show that this danger is not illusory. • Taking the proper motion in parallel I find that of eighty-three stars between 10^h and 12^h R. A., thirty-nine have a proper motion of $0''.10$ or upwards annually, while from 16^h to 18^h R. A. only twenty-one out of ninety-eight stars move with this apparent velocity. There seems strong reason to believe that this difference is not due to the greater velocity or greater nearness of the stars between 10^h and 12^h R. A., but to their different positions with regard to the apex of the sun's way. Indeed it does not extend to the proper motions in N. P. D.

Besides the objectionable methods employed, it seems to me that our catalogues of proper motions are by no means free from systematic errors. It is to this cause I think that any considerable preponderance of diminishing or increasing Right Ascensions in an extensive catalogue must be ascribed. If the great majority of the stars returned to their places a little before or a little after the supposed expiration of the sidereal year, the inference would be that the supposed sidereal year was either a little too long or a little too short. In the two catalogues which I examined—that used by Mr. DUNKIN and one of Southern stars (by Mr. STONE) used by Mr. PLUMMER—I find a large preponderance of dimin-

ishing Right Ascensions. To make the diminishing and increasing Right Ascensions balance, we require to reckon not only $0^s.000$ but $-0^s.001$ as increasing Right Ascensions in Mr. DUNKIN'S (or rather Mr. MAIN'S) catalogue, while for Mr. STONE'S catalogue the correction necessary for this purpose amounts to $+0^s.004$. The results produced by these corrections exhibit no slight degree of symmetry, and if such corrections are really requisite, the most elaborate mathematical computations based on the uncorrected motions are not likely to afford very satisfactory results.

The only remaining course—at least until we have a larger supply of spectroscopic proper motions to refer to—is to abandon classification altogether and with it to abandon all suppositions as to the relative distances of the stars. We must then disregard the amount of the proper motion in each case as depending on matters which we cannot ascertain, and attend to the directions only. These directions are, I think, sufficient to determine the position of the sun's apex, provided that the stars examined are sufficiently numerous and varied. I endeavored to apply this method to Mr. DUNKIN'S 1167 stars, but the number did not appear to be sufficient for an exact determination. I therefore divided the Right Ascension into intervals of 1 hour or 15° only, and first tabulated the increasing and diminishing North Polar Distances (reckoning a star which has no motion in N. P. D. as one-half to each).

Limits of R. A.	No. of Stars with increasing N. P. D.	No. of Stars with decreasing N. P. D.	Limits of R. A.	No. of Stars with increasing N. P. D.	No. of Stars with decreasing N. P. D.
h. *h.*			*h.* *h.*		
0 to 1	31	8	12 to 13	23½	13½
1 to 2	43½	10½	13 to 14	28	12
2 to 3	51½	6½	14 to 15	28½	12½
3 to 4	38	6	15 to 16	39½	13½
4 to 5	42	4	16 to 17	22½	21½
5 to 6	48½	11½	17 to 18	26	30
6 to 7	34	6	18 to 19	35	23
7 to 8	30½	9½	19 to 20	33½	38½
8 to 9	33½	11½	20 to 21	33	31
9 to 10	29½	9½	21 to 22	32½	16½
10 to 11	33½	9½	22 to 23	32	22
11 to 12	27½	12½	23 to 24	32	18
Total				810	357

The great preponderance of increasing North Polar Distances in this table clearly indicates that the apex is situated in the Northern Hemisphere, and I may add that its North Declination is considerable, since if it lay near the equator the preponderance of increasing North Polar Distances would not be so great. Next we have to note that there are two regions in which diminishing North Polar Distances ought to be preponderate, viz: between the apex and the North Pole and between the ant-apex and the South Pole. The Southern stars in the catalogue which I am examing are comparatively few, especially at high Southern Declinations, and therefore the table exhibits but faint traces of this second region. The apex clearly lies between the 16th and 21st hours of R. A. and notwithstanding the curious deficiency of diminishing North Polar Distances between the 18th and 19th hours, that interval seems to be the most probable position for the apex. It will be noted too that the region in which diminishing North Polar Distances preponderate is too large to justify us in placing the apex very near the North Pole. A declination of about 45° will, I think, best explain the phenomena on the whole.

I then formed a similar table for the proper motions in Right Ascension adopting the correction already suggested, but this correction has only the effect of converting a relative into an absolute preponderance of increasing Right Ascensions in one part of the sky and hardly affects our conclusions as to the most probable position of the apex.

Limits of R. A.	No. of Stars with increasing R. A.	No. of Stars with decreasing R. A.	Limits of R. A.	No. of Stars with increasing R. A.	No. of Stars with decreasing R. A.
h. *h.*			*h.* *h.*		
0 to 1	24	15	12 to 13	12	25
1 to 2	31	23	13 to 14	11	29
2 to 3	28	30	14 to 15	12	29
3 to 4	28	16	15 to 16	26	27
4 to 5	31	15	16 to 17	18	26
5 to 6	46	14	17 to 18	23	33
6 to 7	24	16	18 to 19	27	31
7 to 8	13	27	19 to 20	41	31
8 to 9	13	33	20 to 21	41	23
9 to 10	11	28	21 to 22	33	16
10 to 11	9	34	22 to 23	38	15
11 to 12	14	26	23 to 24	33	17

Here, if A be the Right Ascension of the apex, there ought to be a preponderance of diminishing Right Ascensions between A and A — 180°, and a preponderance of increasing Right Ascensions between A and A + 180°; while there should be two neutral points corresponding in Right Ascension with the apex and ant-apex respectively. The first of these neutral points is indicated by the change from a preponderance of increasing to one of diminishing Right Ascensions as we pass from the interval 6^h to 7^h to the interval 7^h to 8^h; the second is indicated by an almost equal distribution between 18^h and 19^h. It is true that there is also a pretty equal distribution between 15^h and 16^h, but this evidently lies in the region where diminishing Right Ascensions preponderate and is due to some accidental cause. The interval 18^h to 19^h is thus again marked out for the Right Ascension of the apex. The preponderance of diminishing Right Ascensions between 7^h and 19^h and of increasing Right Ascensions between 19^h and 7^h is moreover large enough to show that the apex cannot be near the North Pole, for in that case the effect in Right Ascensions would be small. With a larger catalogue we could adopt smaller intervals in Right Ascensions and intervals of Declinations also; and with a larger proportion of Southern stars we could determine the position of the ant-apex as well as that of the apex, and use the former as a check upon the latter; and it is one advantage of this method that the process itself shows the degree in which its results may be relied on. My rough estimate of 280° + 45° may be erroneous to the extent of several degrees in both Right Ascensions and Declination, but I think it will be found nearer to the truth than 264° + 25° which Mr. DUNKIN deduced from the same data by applying the method of least squares to the proper motions of the stars as classified by him. The reduction in the sum of the squares of the motions effected by Mr. DUNKIN was moreover very small, whereas the figures given above seem to imply that the apparent proper motions of the stars are largely dependent on the motion of the sun.

But can we by this method ascertain the velocity with which the sun is moving through space? I think we can, as soon as spectroscopic observations have enabled us to estimate the average velocity of the stars. Assuming that the stars are moving indifferently in every direction, one-half of them will be approaching and the other half receding from any point which we may select, and taking the earth as such a point, the spectrocope will

give us the average rate of approach or recession. The North Pole, for instance, is another such point. Half of the stars will be receding from it and the other half approaching it, in consequence of their own laws; but the effect of the sun's motion is to convert the approach into an apparent retrogression in the case of all stars whose velocity of approach is less than that of the sun. Supposing for example that the sun is approaching the North Pole with the average velocity of an approaching star, one-half of the approaching motions will be changed to apparent recessions and the receding stars will outnumber the approaching in the ratio of three to one. According to the catalogue which I have been considering, the increasing North Polar Distances fall somewhat short of this proportion so that the sun's velocity in the direction of the North Pole is a little less than the average of spectroscopic velocities. How much less could, I believe, with sufficient data be determined exactly, and if we know the velocity with which the sun is approaching the North Pole and the exact position of the apex, we can easily compute the velocity in the direction of the apex. My present rough estimate of this velocity is about twenty miles per second, but this may be erroneous by several miles. A catalogue of the proper motions of not less than 10,000 stars would I think be requisite for any computation whose results could be relied on as fixing the position of the apex within two or three degrees, or as determining the sun's velocity without a considerable percentage of possible error. But the method which I have been advocating requires but little mathematical computation and could be applied to 10,000 stars with less labor than the current methods could be applied to 500.

II. THE SUN'S MOTION IN SPACE.

By W. H. S. Monck.

In a paper already communicated to this Society I expressed my opinion that the apparent proper motions of the fixed stars are much more largely dependent on the sun's motion in space than is commonly supposed by astronomers, and that the contrary conclusion was chiefly deduced from erroneous assumptions as to the magnitudes and distances of the stars whose proper motions were under consideration. I have since examined M. Bossert's